AIRBORNE IN SITU MEASUREMENTS OF $H_2O_{(v)}$ AND $J(NO_2)$ IN SUPPORT OF THE INTERCONTINENTAL CHEMICAL TRANSPORT EXPERIMENT

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We propose to provide airborne measurements of water vapor [H_2O_v] and the photolysis rate of NO_2 [$J(NO_2)$] on board the NASA DC-8 aircraft in support of the Intercontinental Chemical Transport Experiment –North America (INTEX) Mission. These data are essential in understanding tropospheric chemistry and are used in climate, photochemical, and radiation studies. The data provided by these sensors will be of benefit to the INTEX science team for the validation of in situ and remote measurements, real-time flight planning, and delineating atmospheric structure. Post-mission analyses and collaboration with participating research organizations will be pursued by providing in situ correlative measurements for validation of both sub-orbital and orbital observations. Water vapor measurements will be made utilizing a cryogenic chilled mirror hygrometer and $J(NO_2)$ will be measured with filter radiometers. A brief background discussion and description of the instrumentation and measurement techniques follow.

Water vapor: An accurate depiction of the atmospheric distribution of water vapor in the troposphere and lower stratosphere has an important role in climate change studies, understanding the dynamics of the atmosphere, and the validation of instrumentation employing remote measurement techniques. The dynamic range of water vapor concentrations encountered throughout the troposphere bridge approximately six (6) orders of magnitude. The majority of instrumentation uses the chilled mirror technique to obtain in situ airborne water vapor measurements. This technique is used primarily because it is capable of fundamental accuracy since it measures a basic humidity parameter, the dew or frost point of a gas. A typical chilled mirror hygrometer measures the concentration of water vapor in a gas by chilling a mirror until a condensate in the form of dew or frost accumulates on the surface and recording the respective surface temperature. There are many models available but only a few effectively provide in situ measurements from airborne platforms.

Water vapor concentrations will be measured using the cryogenically-cooled, chilled mirror hygrometer (Buck Research model CR-1). This instrument has a wide dynamic range (-90 to +30 C or approximately 1 to 30,000 ppmv H_2O) and reasonably rapid response time (2 to 20 seconds, depending on the temporal and quantitative characteristics of the change in water vapor concentrations). The model CR-1 hygrometer utilizes a cryogenically chilled mirror and electro-optical technique to determine the dew/frost point of a gas. The primary difference between the CR-1 and other chilled mirror hygrometers is the mechanism used to cool the mirror surface. The mirror surface on which the dew/frost layer is preserved is coupled to a rod cooled by LN_2 cryogen. The mirror surface is heated to the dew/frost point by means of a heater winding attached to the mirror rod. A control circuit controlled by optics monitors the reflectance from a LED off the mirror surface and maintains the condensate layer at a preset level. A thermistor embedded in the mirror measures the surface temperature and is output as a direct reading of the dew/frost point of the sample gas.

Air samples for the CR-1 hygrometer will be provided by a separate window-mounted droplet-excluding inlet probe which has been used aboard the DC-8 platform in previous field missions. The in situ sampling probe consists of a stainless steel tubing inlet probe insert combined with a Rosemount type102 non-deiced temperature sensor housing. This type forward-facing probe provides inboard sampling of ambient air while maintaining efficient inertial separation of droplets and particles from the sampled air stream. The outer structural portion of the probe is manufactured by Rosemount Aerospace, Inc. and is flight-certified for use aboard both research and commercial jet aircraft. In normal subsonic flight, the inlet is self-pumping and develops enough pressure head to provide up to 15 liters/minute airflow through the approximately the 1 meter of ¼ " stainless steel tubing which connects the inlet to the sensors. The tubing used to supply the sample air to the hygrometer is heated to approximately 50° C to avoid any chance of internal condensation in the sample line and reduce errors associated with wall effects.

Photolysis frequency of NO_2: Calculated photolysis rates of various trace species provide a significant source of uncertainty in photochemical models. The photolysis frequency of NO_2 plays a critical role in atmospheric chemistry, the accuracy of photochemical models, and provides important information regarding the local photochemical environment. Airborne $J(NO_2)$ measurements provide an opportunity to provide a comprehensive observational data set to help understand various photochemical processes (e.g. O_3, NO_x, HO_x, aerosols) and may also be useful in determining modeled values for cloud effects .

The photolysis rate of NO_2 is predominately dependent on the actinic flux in the wavelength region of 310 to 420 nm. A photoelectric measurement of the actinic flux filtered through selected optical cut-off filters bracketing this wavelength region yields an accurate measurement of the NO_2 photolysis rate. The $J(NO_2)$ filter radiometer (MeteorlogieConsult, Glashutten, Germany) is based on the concept of Junkerman et. al., 1989 (J. Atm. Chem., 1989, 8: 203-227). The collected radiation is optically filtered by a glass filter combination of 2mm UG3 + 1 mm UG5 and detected by a photomultiplier tube. The analog signal of the filter radiometer is a function of the broadband integrated actinic flux between the desired wavelength region. The optics of the radiometer consists of a diffusively transmitting quartz dome that has a nearly uniform angular response over 2π sr for each radiometer. The direct measurement of the actinic flux over 4π sr is achieved by utilizing nadir and zenith-viewing instruments. Further caution is taken to provide accurate measurements of total $J(NO_2)$ by outfitting both nadir and zenith-viewing instruments with black shadow rings to block reflective effects from aircraft wings and fuselage. Sensitivity of the radiometers decreases at approximately 80° from zenith and close to zero at 100° zenith angles (relative to detector). Because the $J(NO_2)$ radiometers measure radiative flux and not NO_2 photolysis rates directly, the instruments are calibrated against an absolute source via chemical actinometry.